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"Developing Improved Reactor Structural Materials Using Proton Irradiation as a Rapid Analysis Tool "

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The objective of this work is to design improved reactor structural materials toward preparation for advanced reactor systems. The work will provide fundamental new knowledge that will improve both environmental cracking resistance and void swelling resistance in reactor structural materials. The tools used to provide this new knowledge will be grain boundary engineering and bulk composition engineering. Radiations will be performed using proton irradiation, which will allow the testing of a large number of materials improvements in a relatively short period of time. This project will also provide fundamental information about radiation damage and lead to improvements in the ability to model radiation effects in structural components. Based on the results of these experiments, a plan will be developed for validating material improvements by using test reactor irradiations.

Two methods will be used to improve environmental cracking resistance and void swelling resistance of reactor components: grain boundary engineering and compositional modification. Grain boundary engineering describes methods used to manufacture desired grain boundary structure and composition. Thermomechanical treatments combined with solute additions will be used to develop crack resistant grain boundaries. Composition modifications will be used to improve swelling resistance without compromising strength. Solute additions that decrease the rate of void nucleation and growth will decrease the swelling for a given irradiation dose. This project will identify a well-chosen set of solute additions that create alloys that are *both* swelling resistant and resistant to environmental cracking.

Year one of the project focuses on compositional modifications. Six different alloys are being irradiated to understand the effect of composition on void swelling and radiation-induced grain boundary segregation (Fe-18Cr-8Ni-1.25Mn, Fe-18Cr-8Ni-1.25Mn-0.08Zr, Fe-18Cr-40Ni-1.25Mn, Fe-16Cr-13Ni-1.25Mn, Fe-16Cr-13Ni-1.25Mn-2Mo, and Fe-16Cr-13Ni-1.25Mn-2Mo-0.05P). The Fe-18Cr-8Ni-1.25Mn alloy will be used as the reference alloy for this project. The major element (Fe, Cr, Ni, Mn) composition corresponds to 304 stainless steel. The effect of major elements on swelling and grain boundary segregation will be studied by comparison of the base alloy with the Fe-18Cr-40Ni-1.25Mn and Fe-16Cr-13Ni-1.25Mn alloys. The effect of minor element composition will be analyzed by comparison with Fe-18Cr-8Ni-1.25Mn-0.08Zr, Fe-16Cr-13Ni-1.25Mn-2Mo, and Fe-16Cr-13Ni-1.25Mn-2Mo-0.05P. The zirconium-containing alloy is being tested to determine the effect of an oversized element on enhancing point defect recombination.